CS 341, Winter 2021 A. Storjohan, H. Zhou

PROGRAMMING ASSIGNMENT 2

DUE: Friday, March 26, 11:59 PM. DO NOT COPY. ACKNOWLEDGE YOUR SOURCES.

Please read `http://www.student.cs.uwaterloo.ca/~cs341` for general instructions and policies.

1. [20 marks] In this programming assignment you will implement your algorithm for the Monotonically Increasing Shortest Path Problem from Assignment 7, Question 2. Here is a reminder of the question:

   Suppose we are given a weighted directed graph $G = (V, E; w)$ with n vertices and m edges. The edge weight w_e could be negative, but we assume there is no negative cycle in G. Given a designated vertex $s \in V$, design an algorithm to compute the length of the shortest monotonically increasing path from s to every other vertex $v \neq s$. A path is monotonically increasing if the weight of every edge on the path is strictly increasing.

   In this programming assignment, in addition to the length of each shortest monotonically increasing path, you also need to compute the s-v monotonically increasing path that achieves the shortest length.

   Write your code in C++ or Python. Your program will be tested to see if it produces the length of the shortest monotonically increasing path from s to v for each $v \in V$ and produces the corresponding monotonically increasing shortest paths (note that the paths may not be unique, so we will not test for an exact match).

   Input and Output. Your program should read from standard input and write to standard output. Assume that $V = \{0, \ldots, |V| - 1\}$.

   The input consists of $1 + |E|$ lines. The first line will contain 3 whitespace delimited integers which are $|V|, |E| \in \mathbb{Z}_{>0}$ and $s \in V$. Then, $|E|$ lines follow where each line contains 3 whitespace delimited integers that are $v, u \in V$ and $w \in \mathbb{Z}$ which represent a directed edge in G from v to u with weight w.

   The output contains $|V|$ lines. The ith line should contain the length d_v of the shortest monotonically increasing path from s to $v = i - 1$, then a colon ":", and then the actual path from s to v (including s, v) delimited by whitespace. If there is no valid path between s and v, print just "inf". If $v = s$, print just "src".

Example.
For the following input:

```
5 8 0
0 1 2
0 2 -2
0 3 5
2 1 1
2 3 8
2 4 -3
3 1 -4
4 3 1
```

the output is:

```
src
-1 : 0 2 1
-2 : 0 2
5 : 0 3
inf
```

Submission Guidelines.

- Programming assignments are submitted through Marmoset:
  https://marmoset.student.cs.uwaterloo.ca/
- Your program will be compiled / run in the student Linux environment using the command "g++ -std=c++14" for C++ and "python3" for Python.
- Submit one zip file containing only your code file which must be named "prog2.cpp" or "prog2.py".
- Your score will be the score of your best submission, which depends on a set of secret testcases.

  You will be able to see some small testcases as a sanity check for your code. In addition, there will be a public testcase which will tell you if your code times out in the largest testcase (but it doesn't test correctness).
- Finally, you can expect the input to satisfy that $|V|, |E| \leq 10^6$, $\max_{e \in E}(|w_e|) \leq 10^3$.